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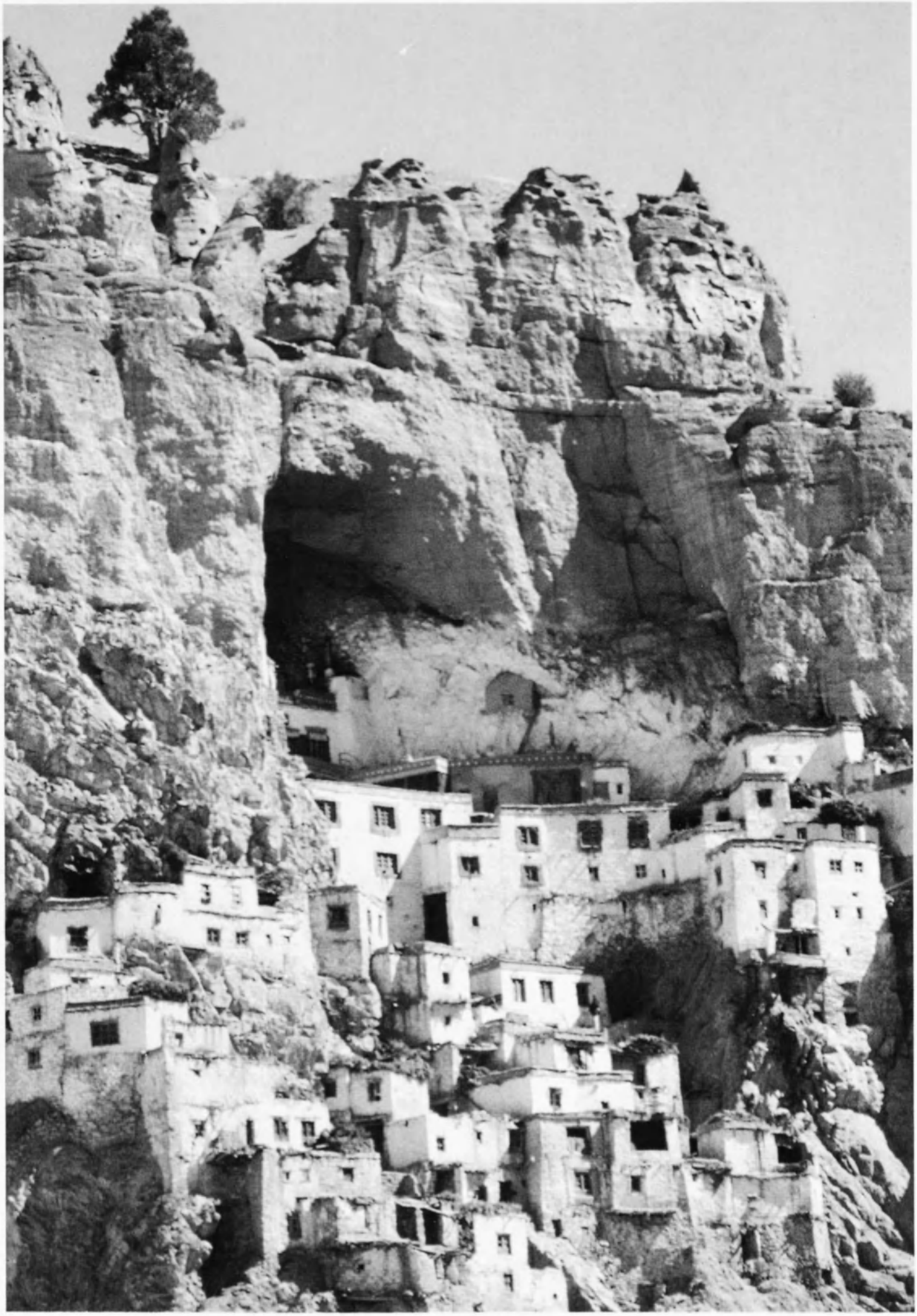
THE FRAGILE FOREST



January 1989

4
The sacred tree
by Jacques Brosse

10
Why we need forests

12
The fragile forest
(1) The relentless march of deforestation
(2) Towards a Green Revolution in forestry
(3) The fuelwood crisis
by Sandra Postel and Lori Heise

15
Facts and figures

21
Rings of time

22
The greenhouse effect

24
Arboreal oddities
Photos

26
Farming the forest
by Malcolm Hadley

29
'Use them or lose them'
A recipe for sustainable use of tropical forests
by Illar Muul

34
The Christianization of Kievan Russia
The Millennium celebrations
by Metropolitan Juvenaly

Cover: Tropical forest in Costa Rica
Back cover: Seven cypresses and twelve branches symbolize the creation and its eternal truths. Detail from a mosaic in the Topkapi palace, Istanbul (Turkey).

◀ Watched over by a single, sacred cedar, the 15th-century monastery of Puktal in the Himalayas recalls the Tibetan legend of the first human couple, born of a forest monkey and the demon of the rock.

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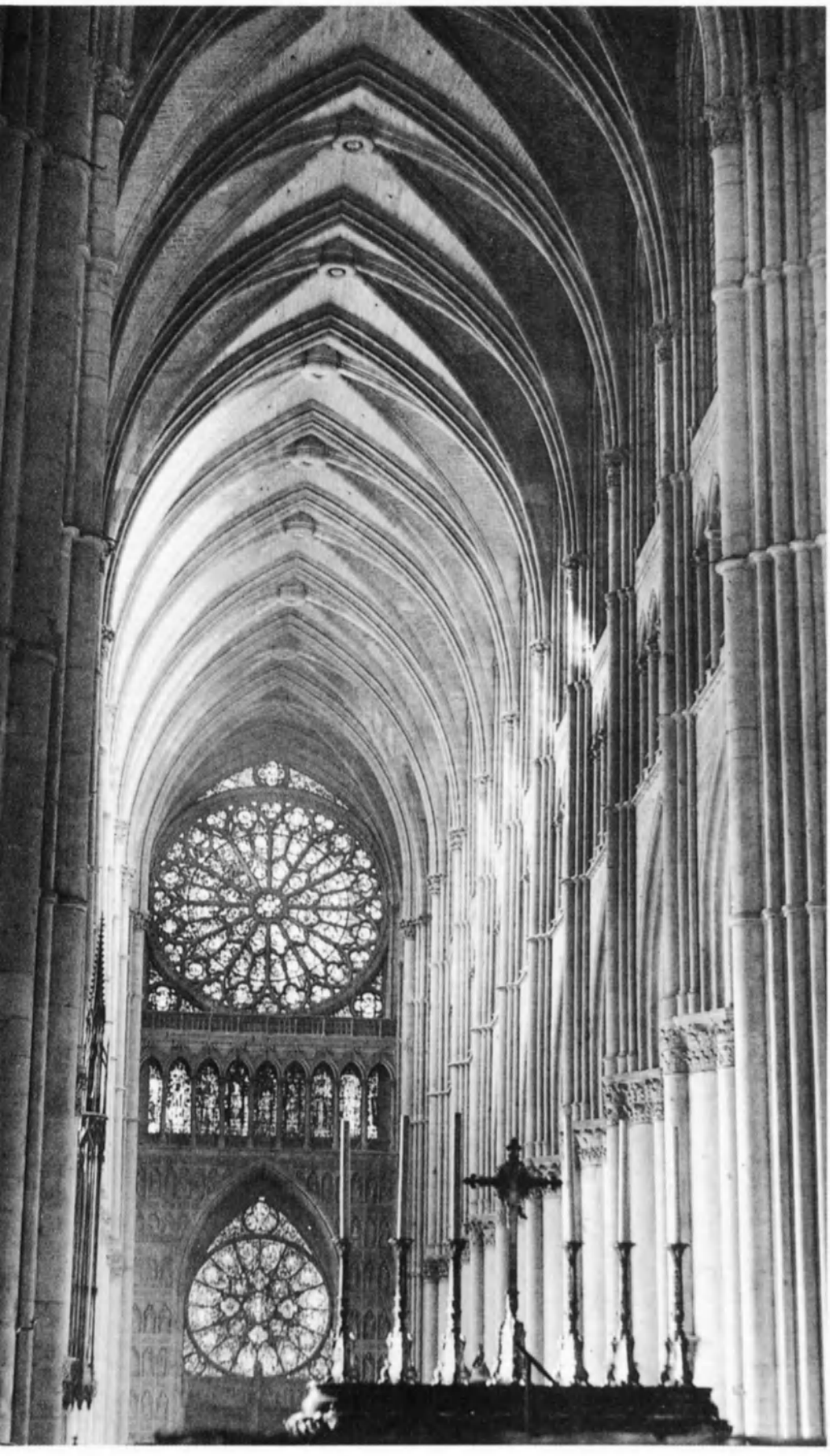
Human beings have a natural affinity with trees. The world's forests cradled our ancestors and nurtured them with nuts, berries and other wild fruit. Later, forests provided the fuel that warmed the cave dwellings of early man and then provided the materials with which he made weapons for hunting and defence, built huts, log cabins and stockades. Long before this, however, the tree, or at least its ancestors of the green plant kingdom, had actually created the conditions which made human life possible.

When the Earth condensed out of a cloud of interstellar gas and dust, some 4,600 million years ago, it was surrounded by a dense atmosphere of cosmic gases made up largely of carbon dioxide and carbon monoxide. This primordial atmosphere was stripped away, but as the planet began to cool and the molten rock solidified, gases, including water vapour, carbon dioxide and nitrogen, were given off and a new atmosphere began to form around the Earth. This, however, was an atmosphere without oxygen; indeed, for the first primitive life forms that began to develop, some 4,000 million years ago, oxygen was a deadly poison.

Then, about 3,000 million years ago, there occurred an evolutionary event of crucial importance—the appearance of organisms that could tolerate the free oxygen they discharged into the atmosphere as a waste product of photosynthesis.

From these organisms developed the plants which are responsible for the oxygen-rich atmosphere which made possible the evolution of animal life, including man. We are all, ultimately, parasites on plants, and in particular on trees, which are the major contributors of the oxygen we need to survive. Trees, therefore, are an essential element in man's life-support system. If we fail to protect them we shall ultimately perish with them.

The sacred tree



THE ties that bound the destinies of men and trees were so strong, among the peoples of every continent, that it is natural to feel anxious about the future prospects of a human race that has broken them. Be that as it may, if an attempt is to be made to avert the very real danger that deforestation represents for our planet, it seems necessary to examine, however briefly, the relationships that existed between men and trees until the present century.

All over the world there lingers on the memory of a giant tree, the primal tree, rising up from the centre of the Earth to the heavens and ordering the universe around it. It united the three worlds: its roots plunged down into subterranean abysses, its loftiest branches touched the empyrean. Thanks to the Tree, it became possible to breathe the air; to all the creatures that then appeared on Earth it dispensed its fruit, ripened by the sun and nourished by the water which it drew from the soil. From the sky it attracted the lightning from which man made fire and, beckoning skyward, where clouds gathered around its crown, it bade the life-giving rains to fall. The Tree was the source of all life, and of all regeneration. Small wonder then that tree-worship was so prevalent in ancient times.

In torrid Egypt the sacred sycamore reigned, and in icy Scandinavia, land of the Teutons, Ygdrasill, the ash. Acvattha, the pipal *(Ficus religiosa)* of India, is identified with Brahman and at its foot the Gautama Buddha attained Enlightenment. In China, Kien-mou, the "erect wood", stood at the centre of the empire and of the world. For the ancient Mexicans, the cosmic tree sprang up in all its many colours from the belly of the earth-goddess in the fifth dimension of space, which unites the upper realm to the lower. Until recently, the sacred tree in Africa was the *kilena* of the Dogon, the *balanza* of the Bambara and the *ase* of the Dahomans, the ancestral tree, the abode of the god and of humanity. Some

BY JACQUES BROSSE

American communities went so far as to regard the sacred tree as the place of their birth.

In most cases, a god uses the tree as his dwelling on Earth, thereby making it sacred; sometimes he speaks to human beings through the medium of the tree. In Greece the oracle of Dodona was given by the rustling of the leaves of the oak of Zeus, which was interpreted by the priestesses officiating in the sanctuary. However, just as the gods come down from the trees, so human beings can climb them in order to reach the sky and meet them there. So it is with the Siberian shaman who goes up into the birch tree; so it is with the Arunta initiate who, in Australia, hoists himself up to the top of the sacred post, in the form of a tree without branches.

Some trees bore the mark of a particular god and were especially revered. But all trees were considered to possess a soul. They were inhabited by spirits whose bodies they formed—dryads, hamadryads and caryatids in Greece, lechy and roussalki among the Slav peoples. Hence no cut could be made in a tree until the tree-spirit had been requested to remove itself. The felling of sacred trees was always punishable by death. Ronsard, the great sixteenth-century French poet, echoed these folk beliefs in his sublime "Elegy Against the Woodcutters of Gâtine".

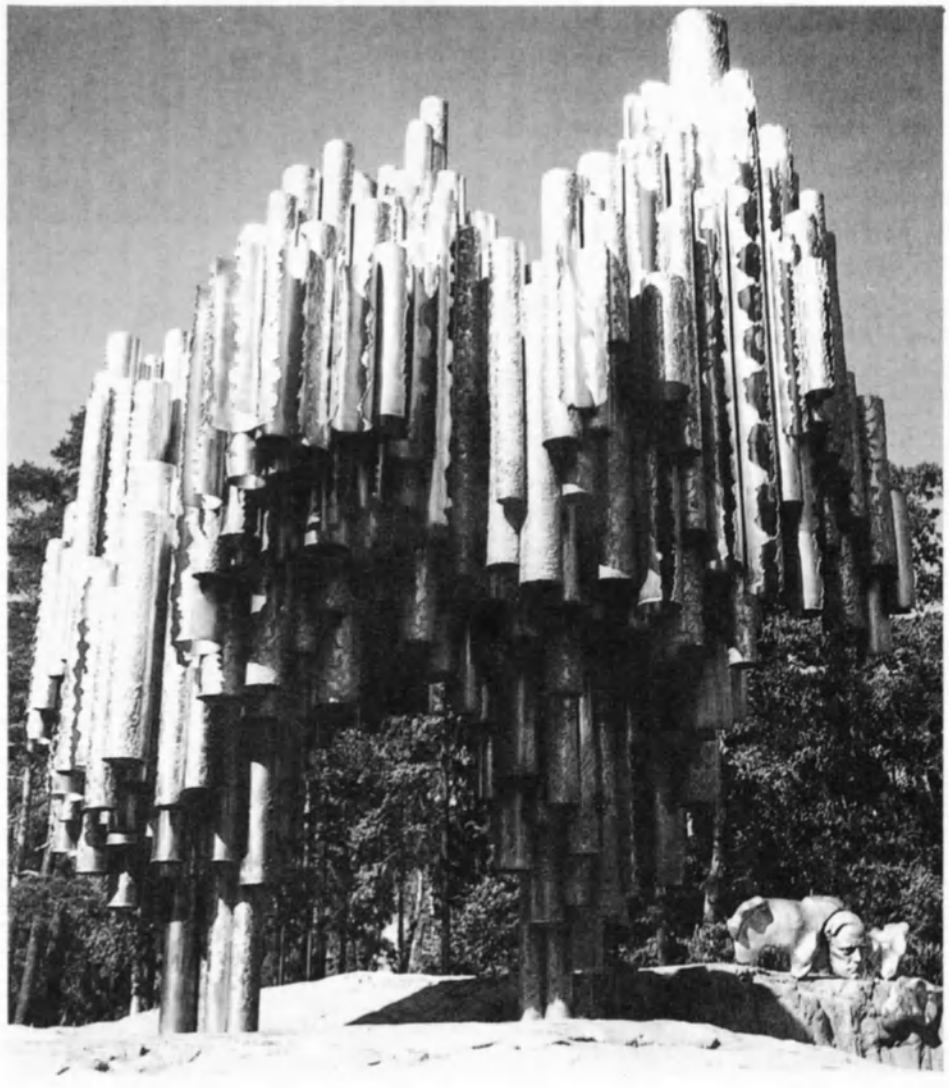
The idea of a divine tree naturally gave rise to a belief in a sacred grove, which achieved the status of a religious institution, not only among the Greeks, Romans and Celts, but also in Iran, throughout Asia, and in Africa and America. Vestiges of these sacred groves still remain in India, China and Japan, and among the Berbers in North Africa. In former times there was no other sanctuary. The sacred grove inspired reverence and fear and was ringed around with severe interdictions, but it was also the place where initiates gathered and received secret oral teachings from the priests. The sacred grove was at the origin of the temple, whose columns were initially trees, and later of the Christian church which still evokes it by the alignment of its pillars, the semi-darkness within it, and the soft, coloured light that filters through its stained glass windows.

In former times kings would sit beneath a majestic tree to administer justice. Sometimes the sacred tree constituted the heart of the city, which it protected, and although in the process of urbanization the traces of this belief nearly always vanished, examples can still be found in the writings of Antiquity. In the centre of Eridu, the holy city, the Sumerians of the third millennium BC worshipped Kiskanu, the cosmic tree. On the Acropolis in Athens grew the olive tree planted by Athena,

▲ Bamboo plantation, Anduze, France

◀ Rheims cathedral, France

▼ "The Forest of Steel", Helsinki. Memorial to the Finnish composer Jean Sibelius (1865-1957)

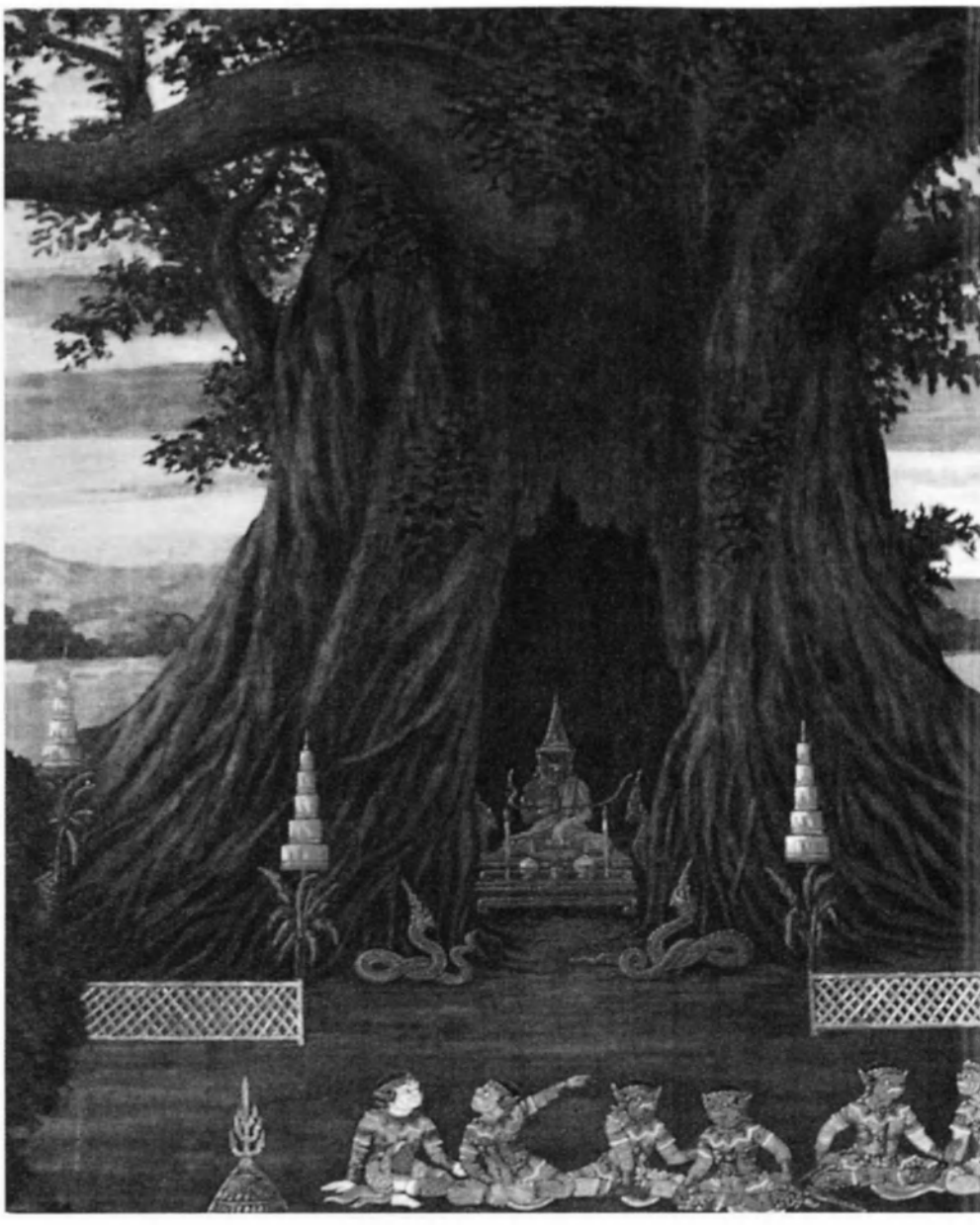


who had by that means taken possession of the land and founded the city. In the forum at Rome grew the fig tree under whose boughs Romulus and Remus were suckled. According to Tacitus the withering of the tree in the year 58 AD was considered to be of ill omen. The following year Nero killed his mother Agrippina and thereafter gave himself up to a life of unbounded cruelty and debauchery, triggering a crisis which almost brought about the downfall of the Roman empire.

As well as being linked to the destiny of cities, trees could also be directly associated with the fate of individuals. A particular tree would be seen as a person's double, affording him protection and communicating to him its vigour and also, so it was hoped, its longevity, which far exceeds that of human beings. All over the world trees were planted on the occasion of a child's birth, and thereafter the twins constituted by the child and the tree would be considered to share the same fate. Great care was taken of the tree, for if it withered, the person would be in danger. Pliny relates that one famous Roman poured wine at the foot of his tree in order to fortify it.

In certain traditional societies, this custom survived into the twentieth century. In some cases the link between a person and a tree was established when an attempt was made to heal a sick child by passing his naked body three times through a split made in the living wood. Once a widespread cure for rickets or hernia, this ritual would usually be carried out at sunrise, when the tree's energy is at its peak. The sick child would draw on this energy and the tree take the sickness upon itself. After the ceremony the edges of the split would be brought together and sealed with clay. In this way a lasting affinity was created between child and tree. If the gash in the tree closed up, the child would be cured, but if it remained open, the sickness would persist. If the tree died, so would the child. When he grew up, a child treated in this way would take great care of his tree. Nobody else would be allowed to touch it.

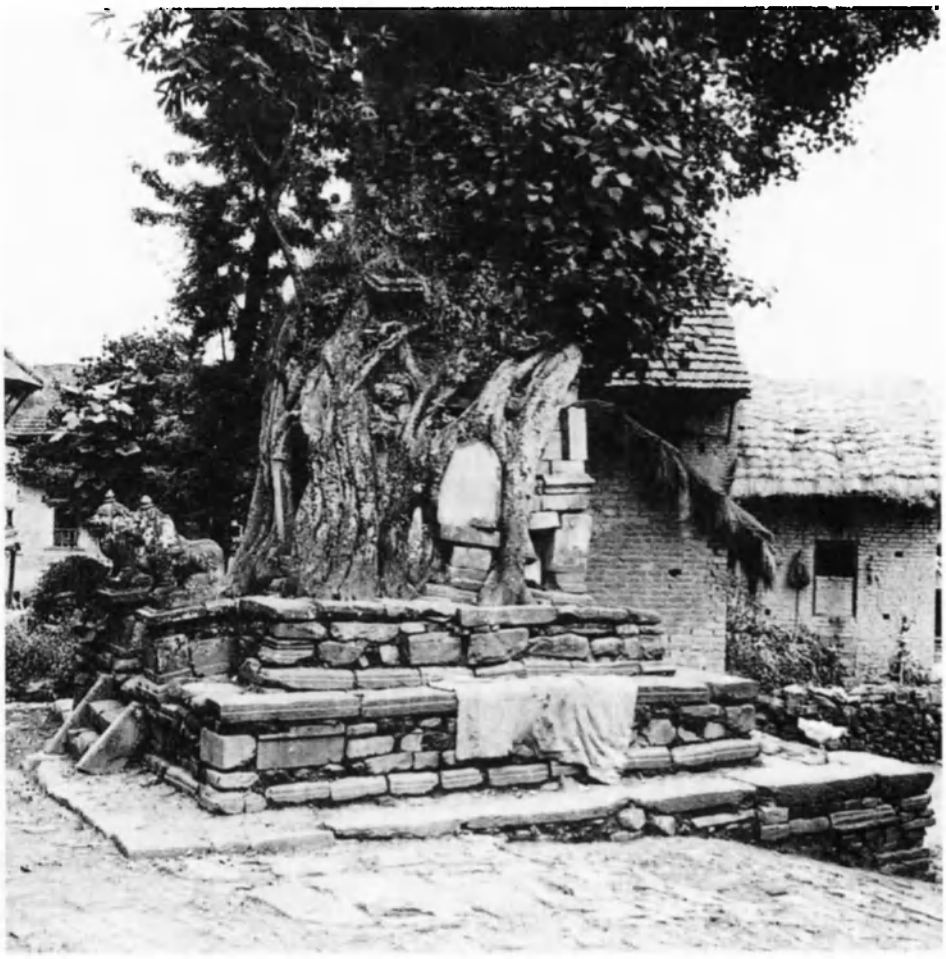
Equally widespread was the belief that trees harboured the souls of the dead. Among some peoples, such as the Warramunga of central Australia, it was thought that trees served as a refuge for souls before their reincarnation. The ancient Egyptians believed that the spirits *(ba)* of the newly-dead would alight in the form of birds on the branches of the sacred sycamore, and that the Lady of the Sycamore, the cow-goddess Hathor, would appear among the foliage and welcome them with water and bread. But often the souls are irascible and dangerous. This was the case in Korea and many other countries, where only the souls of those who had died a violent death took shelter in trees.



Elsewhere trees were believed to harbour souls who had been condemned to remain on Earth in order to atone for their sins. In his *Légendes de la mort en Basse-Bretagne* ("Legends of Death in Lower Brittany"), the French folklorist Anatole Le Braz described remarkable examples of such beliefs as late as the end of the last century. Long ago a dead man was sometimes seen in a tree where he could be heard moaning and groaning. Masses then had to be said for him in the parish church and afterwards he came to thank the person who had thus delivered him. Sometimes trees could be heard walking in the night towards a house where they again became the kinsfolk of the proprietor and warmed themselves at his hearth.

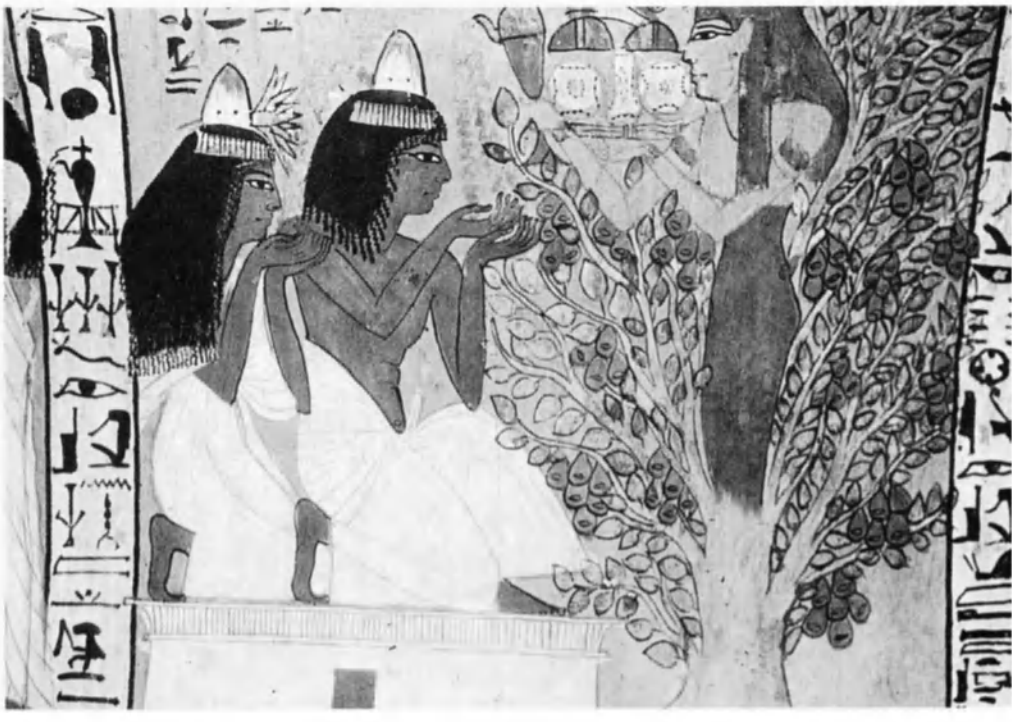
The choice of trees to be planted in graveyards thus had to be made with the utmost care. In Brittany the yew was chosen as the funerary tree whose roots grew down into the mouths of those who were buried beneath it. In the Mediterranean region the funerary tree is always the cypress, a symbol of mourning as long ago as the Cretan era, but also, on account of its shape which suggests an eternal flame rising heaven-

Fresco in the royal palace, Bangkok, depicting the "Bodhi" tree beneath which Gautama Siddhartha achieved enlightenment, to become the supreme Buddha.



Above, pipal tree with altar, Kirtipur, Nepal

Below, Egyptian goddess Hathor, Lady of the sacred sycamore



wards, a symbol of prayer and a pledge of immortality. In China too the cypress or another evergreen, the pine, were chosen to be planted over graves.

For our ancestors, who were attentive observers of Nature, the different species of tree also corresponded to, and in a sense illustrated, the rhythm of the seasons. In Europe there was in ancient times a tree calendar which the British poet and scholar Robert Graves succeeded in piecing together again in its most recent form, as it was known to the Celts when it formed part of the esoteric teachings of the Druids. However, Graves showed that the tree calendar dated from a much earlier period since it was already familiar to the Greeks in pre-classical times. The Celtic calendar was also an alphabet, paralleling in this the mnemonic techniques used for the

purposes of exclusively oral instruction by those peoples who prohibited writing in order to guard against the divulgence of knowledge that was by its nature sacred and hence secret.

The tree calendar was called *Beth-Luis-Nion*, from the names of the first three trees of the year, *Beth*, the birch, *Luis*, the rowan, and *Nion*, the ash. *Beth*, *Luis* and *Nion* were three consonants in the early Irish alphabet, which contained thirteen of them, corresponding in Graves' view to names of trees. The calendar as restored by him should be set out as follows:

B for *Beth*, the birch:
24 December-20 January

L for *Luis*, the rowan:
21 January-17 February

N for *Nion*, the ash:
18 February-17 March

F for *Fearn*, the alder:
18 March-14 April

S for *Saille*, the willow:
15 April-12 May

H for *Uath*, the hawthorn:
13 May-9 June

D for *Duir*, the oak:
10 June-7 July

T for *Tinne*, the holly:
8 July-4 August

C for *Coll*, the hazel:
5 August-1 September

M for *Muin*, the vine:
2 September-29 September

G for *Gort*, the ivy:
30 September-27 October

P for *Peith*, the whitten:
28 October-24 November

R for *Ruis*, the elder:
25 November-22 December

The calendar was based on the lunar year which, consisting of thirteen months of twenty-eight days, comprised only 364 days. There thus remained an intercalated day, 23 December, the eve of the winter solstice in this calendar. This was the most ill-omened day of all because it was then that the year died. It was consequently represented by the yew, the death-tree. The following day, however, 24 December, when the sun begins again to climb towards its zenith, the time of Christmas and the birth of the Divine Child, was governed by the silver fir, the birth-tree.

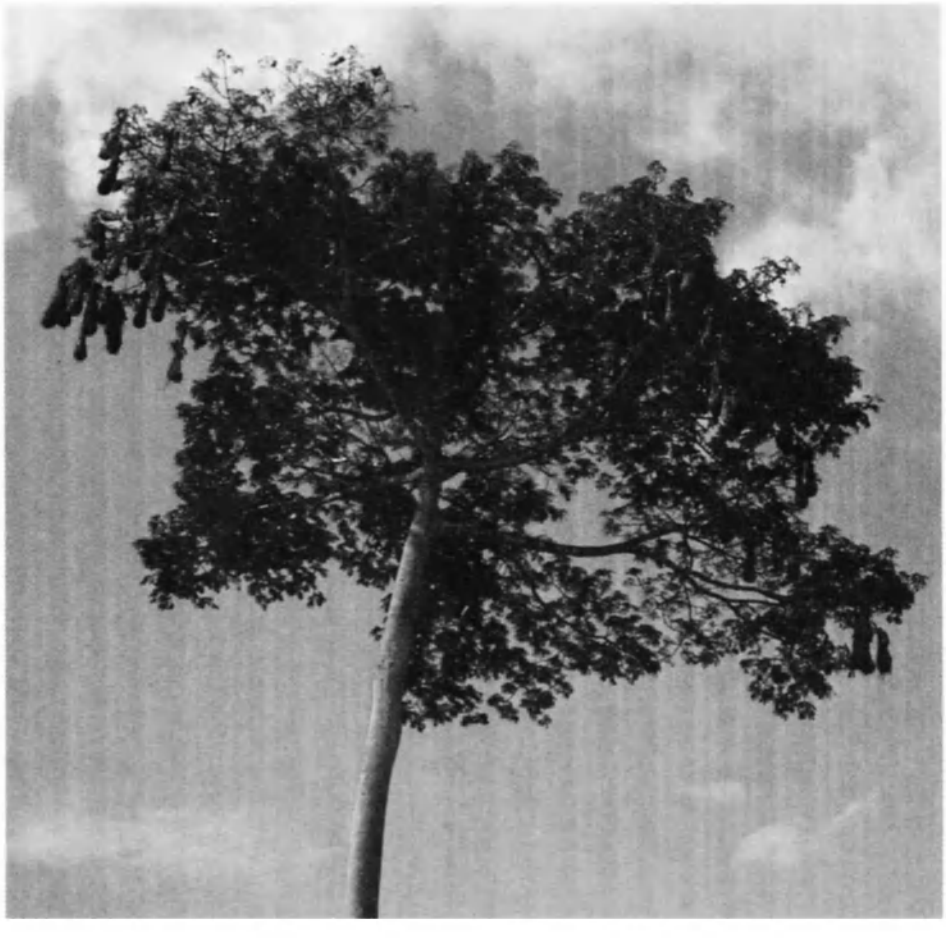
The trees in the tree calendar were not chosen at random. Each one was associated with the month when it was at the height of its beauty, in flower or bearing fruit. Account was also taken of the correspondence between the symbolic value of each species and the time of the year associated with it.

Does any trace remain of this tree calendar? If February is the only month to have retained the same number of days as the lunar month, plus one intercalated and therefore ill-omened day every four years, it is because it was formerly the month of great purifications whereby preparations were made for the rebirth of the vegetation and the approach of more clement weather. May gave its name to the may tree, generally the hawthorn, as in the tree calendar, which was planted all over Europe on the occasion of festivities among village communities, in order to celebrate the triumph of spring over winter. And as for the silver fir of 24 December, it has become our Christmas tree.

Man's brief passage on Earth is symbolized by this illustration from an Etruscan vase, right. Man is seen poised between the tree of life and the tree of death.

Below, the tree, symbol of Christ, flanked by two horses representing believers. Roman mosaic in the Bardo Museum, Tunis.

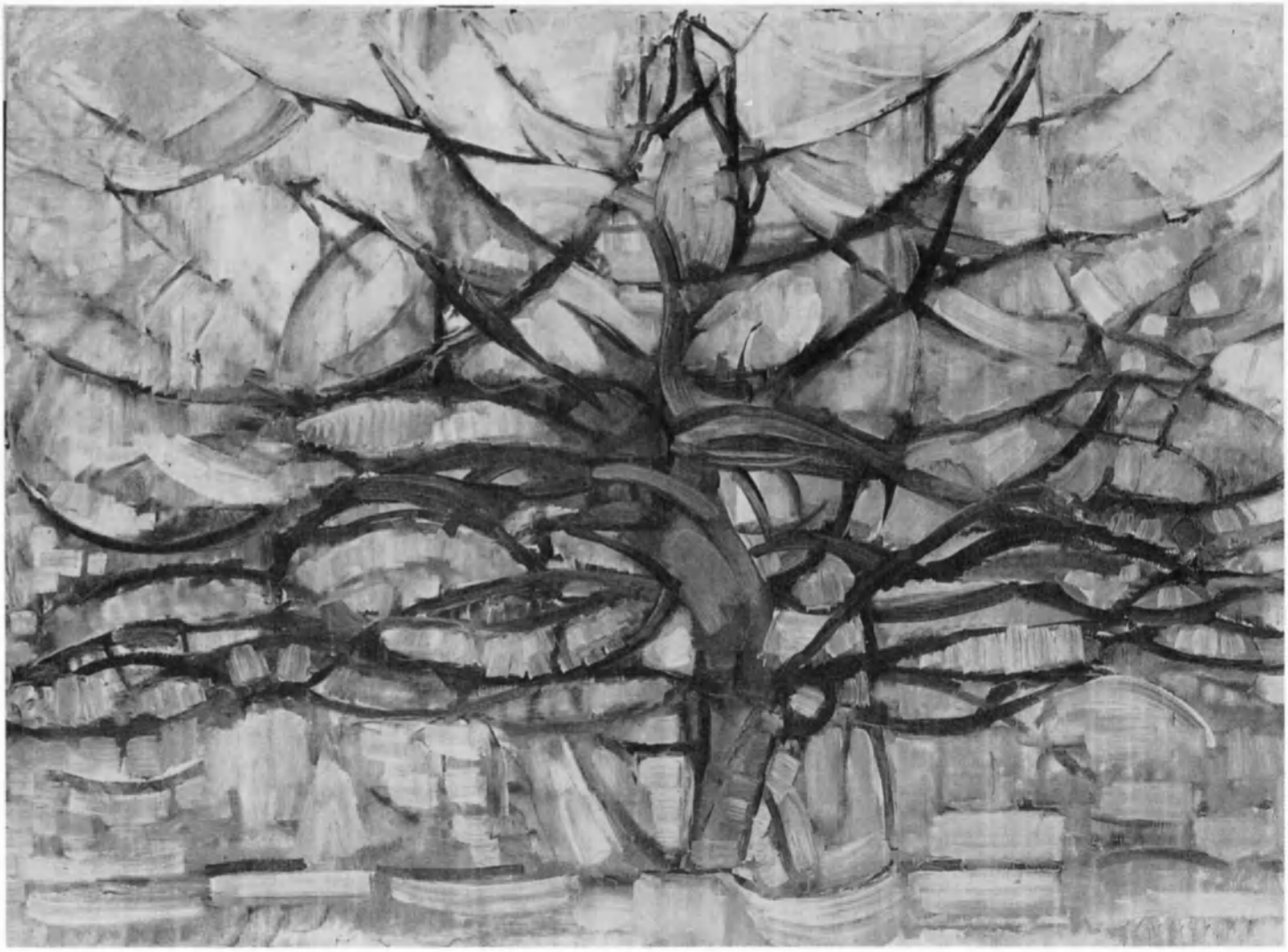
The Maya Indians of Central America believed that the Ceiba, or silk cotton tree (below), was the first tree and the source of all life.



What lessons can be drawn from this multiplicity of beliefs whose universal character we have just seen? If we considered trees to be divine, attributed souls to them and treated them as models for human beings, would we not be yielding to superstitions from another age, to obscure, outdated beliefs unworthy of a civilization that purports to be rationalistic, scientific and strictly materialistic? In fact, however, it is the scientists themselves who are beginning to call into question this dismissive attitude. In the 1920s, an eminent Indian physiologist and botanist, Sir Jagadis Chandra Bose, demonstrated by experiment that plants have a real sensibility and a capacity for memorizing which correspond to a very rudimentary form of mental life. His experiments have since been verified and supplemented by American and especially by Soviet scientists. In other words, the watertight divisions that, in the name of an excessive rationalism, were thought to exist between plants and animals, and between animals and human beings, appear unfounded. In a less controversial area, phytotherapists and ethnobotanists are at present regaining acceptance for traditional plant remedies, virtually abandoned not so long ago, many of which derive from trees. In many cases it can even be said that certain superstitions of bygone days are now acknowledged to be based on real observation.

The Swiss psychologist and psychiatrist Carl Gustav Jung (1875-1961) showed that the image of the tree still survives as an archetype in the individual and collective unconscious. Indeed, it is one of the most fertile, vital and universal symbols. In a time of crisis like the present, it is in himself that man might usefully rediscover the meaning of that image and at the same time recover a sense of union with Nature, of cosmic harmony which, unhappily for him, he has often lost. ■

JACQUES BROSSE, French naturalist and writer, has published several books on trees and tree myths. One of them, *Les arbres de France: histoire et légendes,* won the 1988 Pierre Delbès Prize, which was established in memory of a noted French agronomist and plant ecologist and is awarded annually for a book which contributes to the study and preservation of the environment. Jacques Brosse's latest work, *Mythologie des arbres,* will be published this year.



The Gray Tree (1912), oil on canvas by Piet Mondrian. Haags Gemeentemuseum, The Hague (Netherlands).

Why we need forests

• The conservation and management of tropical forests are matters of vital importance for the peoples of the countries in which they are situated (some 1,600 million people, about a third of the world's population, live between the Tropics of Cancer and Capricorn).

• With their unique diversity of plant and animal life, tropical forests represent an immense, renewable source of food, fibre, medicines and fuel. If properly managed they can provide a wealth of useful products and values.

• They provide timber and paper and are an important source of foreign currency earnings for tropical countries.

• The inappropriately-named minor forest products (all products other than timber) can also be of considerable commercial importance. Rattan, for example, has an estimated annual value in world trade of $1,200 million and tends to benefit local villagers much more directly than many timber operations.

• Other forest products include bamboo, resins, food, medicinal plants, pharmaceutical products, mushrooms and honey. One conservative estimate values the annual trade in these products at $10,000 million.

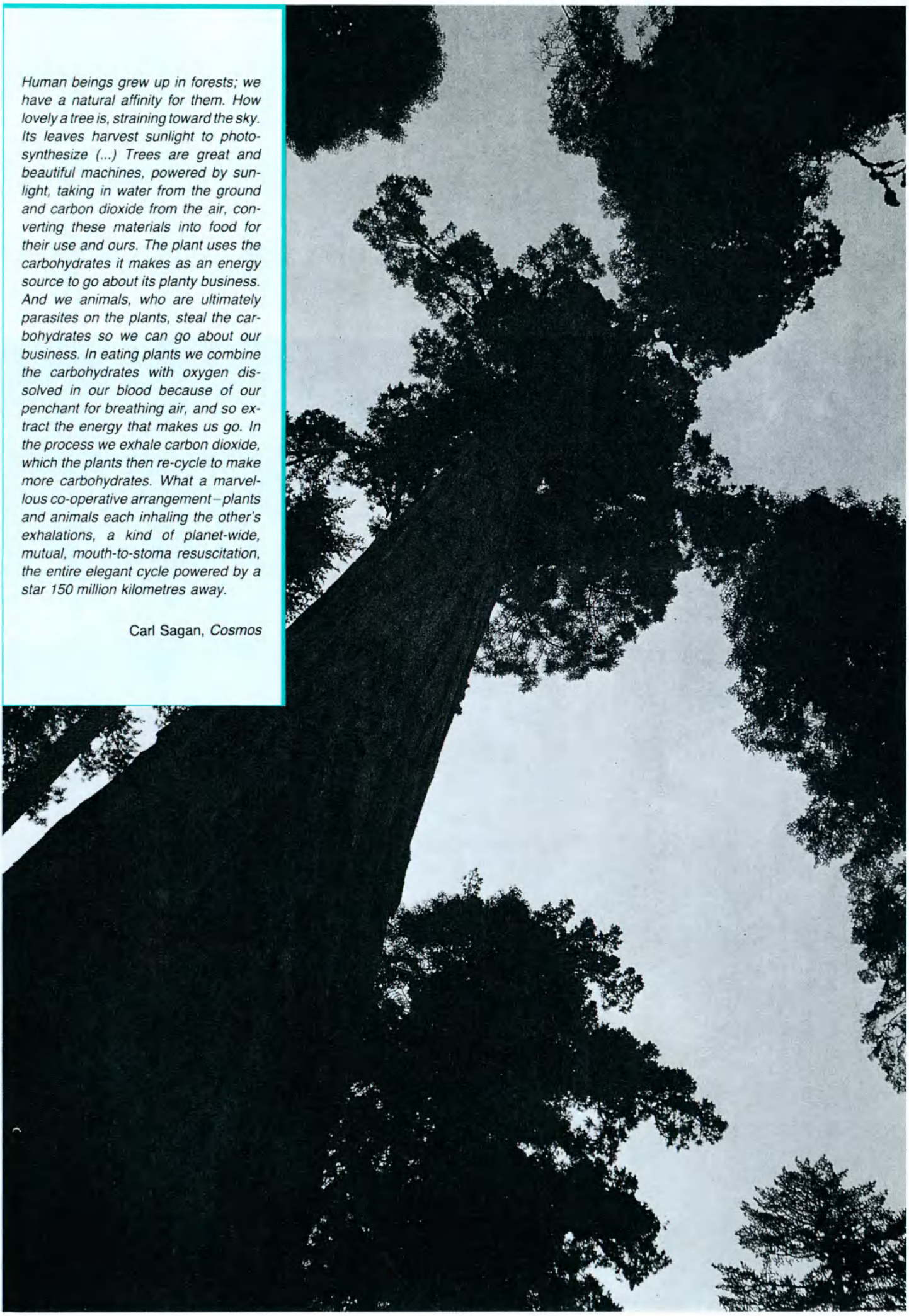
• Tropical forests fulfil other important functions. They help in the regulation of the quality and flow of water and they protect soils from erosion. They are also of great cultural, spiritual and aesthetic significance to the peoples of the tropics.

• Forests are of concern to the world community as a whole. They affect the climate by helping to maintain the Earth's temperature and are a significant element in the Earth's carbon budget.

• The rare trees and plants of which they consist constitute a gene pool whose value has only just begun to be explored in the search for drugs to cure some of mankind's most serious diseases.

Human beings grew up in forests; we have a natural affinity for them. How lovely a tree is, straining toward the sky. Its leaves harvest sunlight to photosynthesize (...) Trees are great and beautiful machines, powered by sunlight, taking in water from the ground and carbon dioxide from the air, converting these materials into food for their use and ours. The plant uses the carbohydrates it makes as an energy source to go about its planty business. And we animals, who are ultimately parasites on the plants, steal the carbohydrates so we can go about our business. In eating plants we combine the carbohydrates with oxygen dissolved in our blood because of our penchant for breathing air, and so extract the energy that makes us go. In the process we exhale carbon dioxide, which the plants then re-cycle to make more carbohydrates. What a marvellous co-operative arrangement – plants and animals each inhaling the other's exhalations, a kind of planet-wide, mutual, mouth-to-stoma resuscitation, the entire elegant cycle powered by a star 150 million kilometres away.

Carl Sagan, *Cosmos*



The fragile forest

BY SANDRA POSTEL AND LORI HEISE

(1) The relentless march of deforestation

BEFORE the dawn of agriculture, some 10,000 years ago, the Earth boasted a rich mantle of forest and open woodland covering some 6,200 million hectares. Over the centuries, a combination of land clearing for crop production, commercial timber harvesting, cattle ranching and fuelwood gathering has shrunk the Earth's forests to some 4,200 million hectares—a third less than existed in pre-agricultural times.

For centuries, this reduction in the Earth's biological stock hindered human progress little, if at all. Indeed, the clearing of trees to expand food production and the harvesting of forest products were vital aspects of economic and social development. But the relentless loss of tree cover has recently begun to impinge on the economic and environmental health of numerous nations, mostly in the developing world. Large-scale reforestation, combined with concerted efforts to protect remaining forests, now appears essential to improving the human prospect.

Most tree planting efforts over the last several decades have aimed at increasing supplies of marketable timber, pulp and fuelwood for cities—forest products that yield obvious economic benefit. By contrast, reforestation for reasons that lie outside the monetized economy has been vastly under-attended. Yet trees quite literally form the roots of many natural systems. With the inexorable march of deforestation, the ecological integrity of many areas is disintegrating—causing severe soil loss, aggravating droughts and floods, disrupting water supplies and reducing land productivity.

Trees are also a vital component of the survival economy of the rural poor. Hundreds of millions of people rely on gathered wood to cook their meals and heat their homes. For them, lack of access to wood translates into reduced living standards and, in some cases, directly into malnutrition. In addition, trees and soils play a crucial role in the global cycling of carbon, the importance of which has been magnified by the emergence of carbon dioxide-induced climate change as arguably the most threatening environmental problem of modern times.

Efforts to slow deforestation certainly deserve redoubled support. But even if forest clearing miraculously ceased today, millions of hectares of trees would still have to be planted to meet future fuelwood needs and to stabilize soil and water resources. Increased planting to satisfy rising demands for paper, lumber and other industrial wood products is also crucial. Expanding forest cover for all these reasons will reduce pressures on remaining virgin forest, helping thereby to safeguard the Earth's biological diversity. At the same time it will mitigate the build-up of atmospheric carbon dioxide, which gives industrial countries sound reason to step up support for tree planting in developing countries.

Successfully reforesting large areas of degraded lands, however, will require much more than financial commitments from governments and international lending agencies. It will take a shift in emphasis from government foresters establishing and maintaining commercial plantations to the much more complex tasks of starting nurseries in thousands of villages and encouraging the planting of multi-purpose trees along roads, on farms and around houses. Only by garnering the know-

ledge, support and human energy of rural people themselves—and planting to meet their basic needs—is there any hope of success.

Dramatic changes in regional forest cover historically reflect powerful societal transformations. Beginning in the sixteenth century, the expanding agricultural and industrial needs of Renaissance societies spurred the clearing of large tracts of forest in Western Europe. France, once 80 per cent forested, had trees covering only 14 per cent of its territory by 1789. Both the French and the English so depleted their domestic forest resources that they were forced, by the mid-seventeenth century, to conduct a worldwide search for ship timbers in order to maintain their maritime superiority. Similarly, forest cover in what is now the contiguous United States totalled some 385 million hectares in 1630, around the time when the Pilgrim Fathers arrived. As colonization spread along the eastern seaboard and gradually westward, forests dwindled. By 1920, trees covered 249 million hectares, more than a third less than when European settlement began.

Despite growing recognition of the importance of forests to the economic and ecological health of nations, surprisingly little is known with certainty about the state of forest resources today. Many countries have not fully inventoried their forests and the data that do exist vary widely in quality. A 1982 study by the United Nations Food and Agriculture Organization (FAO) still provides the best information available on tropical forests, even though much of the data is more than a decade old. Combining FAO's estimates with those of a 1985 forest assessment by the United Nations Economic Commission for Europe and with various individual country reports yields a rough picture of the global forest resource base.

Closed forest, where the shade from tree crowns prevents substantial growth of grass, covers nearly 3,000 million hectares worldwide. Another 1,300 million hectares are open woodlands, including, for example, the wooded savannah of Africa and the cerrado in Brazil. Collectively, forested lands cover approximately 4,300 million hectares, an area almost triple that in crops. Shrubland and forest regrowth on temporarily abandoned cropland bring the total area supporting woody vegetation to more than 40 per cent of the world's land.

Pine trees affected by acid rain in the Vosges mountains, France. Some 31 million hectares of forest in central and northern Europe show signs of damage from acid rain and other forms of atmospheric pollution.

A forest plantation in Borneo, Indonesia. Plantation forestry is slowing, but not preventing, deforestation. FAO reports that in the early 1980s 11.3 million hectares of tropical forest were cleared annually, while only 1.1 million hectares of plantations were established.

The most worrisome finding of FAO's assessment was that tropical trees were being cut much faster than reforestation or nature were replacing them. For tropical regions as a whole, 11.3 million hectares were cleared annually in the early 1980s, while only 1.1 million hectares of plantations were established. Thus ten hectares were being cleared for every one planted. In Africa, the ratio was twenty-nine to one; in Asia, five to one. Even these alarming figures probably underestimate the extent of forest loss in particular regions, since tree planting is often highly concentrated, while cutting is widespread.

Recent data for individual countries suggest that forest cover trends in some regions are even bleaker than FAO's

sobering assessment indicates. Satellite imagery of five States in Brazil, for example, shows that deforestation in parts of the Amazon has proceeded much faster than estimates for the entire region suggest. Likewise, LANDSAT data released by the National Remote Sensing Agency of India reveal that India's forest cover declined from 16.9 per cent in the early 1970s to 14.1 per cent in the early 1980s, an average loss of 1.3 million hectares per year. Fortunately, reforestation is also proceeding somewhat faster than official estimates suggest. Spontaneous tree planting by villagers around farm fields, as windbreaks, or along roadways is frequently not counted. Indeed, forestry statistics typically ignore "trees outside of forests", even though in many areas they are the primary source of fuelwood, fodder and rural construction materials. In Kenya, for instance, the number of trees planted by villagers exceeds the number established in government plantations. And in Rwanda, scattered trees planted by rural people collectively cover some 200,000 hectares, more than the combined area of the country's remaining natural forest and all State and communal plantations.

Nonetheless, the loss of forest cover in tropical countries remains rampant. Conversion of forest to cropland is by far the leading direct cause. Population growth, inequitable land distribution and the expansion of export agriculture have greatly reduced the area of cropland available for subsistence farming, forcing many peasants to clear virgin forest to grow food. These displaced cultivators often follow traditions of continuous cropping that are ill suited to fragile forest soils. Eventually, the soils become so depleted that peasant colonists must clear more forest to survive.

Indigenous "shifting cultivators" clear new fields every few years, allowing forest regrowth to restore soil fertility before they return to clear and plant again several years later (see article page 26). But even this once sustainable practice is being undermined as population pressures force farmers to recultivate

FACTS AND FIGURES

- It is estimated that each year between 11 and 15 million hectares of tropical forest (an area larger than Austria) are lost.
- Tropical forests, which cover only 7 per cent of the world's land area, contain over half the known plant and animal species, including 80 per cent of insects and 90 per cent of primates.
- Half the world's main crops originated in tropical forests.
- 25 per cent of drug prescriptions in the United States owe active ingredients to plants, but under 1 per cent of species have been investigated. It is thought that about 1,400 forest plants may have anticancer potential.
- 50,000 square kilometres of closed tropical forest are logged annually. Loggers take only between 4 and 10 per cent of trees, but leave up to one third of the land surface bare and open to erosion.
- 80 per cent of all forest lands are owned by governments.
- Europe accounts for 40 per cent of global trade in tropical timber by volume and 32 per cent by value.
- Over half the European imports of tropical timber are used for building and joinery. The remainder goes mostly for plywood, furniture, transport, packaging and water resistant pilings.

Data from the World Wildlife Fund's *Special Report on Conservation of Tropical Forests*

The establishment of logging camps and access roads can involve the destruction of large numbers of commercially valueless trees.

In Latin America large areas of tropical forest are cleared each year to create pasture for cattle ranching.

land before it has recovered. FAO estimates that the breakdown of traditional shifting cultivation patterns is responsible for 70 per cent of closed forest clearings in tropical Africa, nearly 50 per cent in tropical Asia and 35 per cent in tropical America.

Population pressures have also transformed fuelwood collection into an unsustainable practice. Given a choice, villagers generally gather dead wood and branches for fuel; they only cut live wood if nothing else is available or if they are converting wood to charcoal for urban markets. Fuelwood collection is thus an agent of forest destruction primarily in the arid woodlands of Africa, where population density is high and the natural growth rate of vegetation is low, and around large cities of Asia and Africa, where concentrated demand over-taxes available tree stock. Recent LANDSAT data show that in less than a decade forest cover within 100 kilometres of India's major cities dropped by 15 per cent or more; Delhi lost a staggering 60 per cent.

Consumer demand in temperate countries also fosters tropical forest depletion. Industrial countries' appetite for tropical hardwoods has encouraged many governments of developing countries to "mine" their forests to earn vital foreign exchange. As loggers fell commercially valuable tree species—which sometimes account for less than 5 per cent of any given hectare—they often destroy between 30 and 60 per cent of unwanted trees as well. Roughly two-thirds of the logging—and the damage—has occurred in Southeast Asia, although logging is likely to increase in Latin America as Asian forests become depleted.

One additional agent of forest destruction operates in Latin America—the lure of cattle ranching. Between 1961 and 1978, pasture in Central America expanded 53 per cent, while forests and woodlands declined 39 per cent. Much of this conversion was driven by US demand for cheap beef, although in recent years Central American beef exports have dropped in response to declining US beef consumption. Similarly, by the late 1970s an estimated 1.5 million hectares of pasture had been established in the Brazilian Amazon. In 1979, Brazil eliminated some of the incentives that had spurred clearing for pasture; alas, forest clearing continues as a way of establishing claims in Brazil's highly speculative land market.

Pressures on temperate forests have waned substantially following several centuries of clearing for agriculture. Forest cover in most European countries is now fairly stable; in some it has even been increasing as marginal agricultural land reverts to woodland and as conscious efforts are made to plant trees. Since the early 1960s, government and private plantings in the United Kingdom have increased net forest cover an average of 30,000 to 40,000 hectares per year. In France, forest area has risen substantially from its historic low of 14 per cent in 1789. About a quarter of the country is now forested.

Unfortunately, chemical stresses from air pollution and acid rain today place a substantial share of European forests at risk. Trees covering some 31 million hectares in central and northern Europe are showing signs of damage linked to air pollutants. Scientists do not know how extensive the damage will become, but it could substantially offset recent gains made in expanding the continent's forested area.

As in Europe, forest cover in the contiguous United States was comparatively stable during most of this century, following the loss of 136 million hectares between 1630 and 1920. During the last two decades, however, forest area has declined as widening grain export markets encouraged conversion of forest to cropland and as urban and

industrial development encroached on woodland. In 1982, forests covered 233 million hectares of the contiguous States—a 10 per cent drop from 1963 and less than existed in 1920, the previous low point.

In the developing countries, nothing in prospect suggests that forest cover will stabilize any time soon as it has in many industrialized countries. The forces behind deforestation remain strong and planting efforts are woefully inadequate to reverse the loss of tree cover. ■

More than two-thirds of all people in the developing countries rely on wood for heating and cooking.

European bison in the Berezinskiy Biosphere Reserve (Byelorussian SSR). Forests are home to several million plant and animal species, and as forests—whether tropical, temperate or boreal—are cut down or disturbed, more and more of these species are threatened with extinction. European bison used to abound in the virgin forest that centuries ago stretched from the Baltic Sea to the River Bug. Relentless overhunting and forest destruction by successive waves of invaders brought the European bison to the verge of extinction. In a notable co-operative effort, 5 of the few bison that remained in the part of the forest on Polish territory were handed over to the Byelorussian authorities. Today several hundred bison flourish in the security of the Belowezhskaya puscha, the oldest forest reserve in Europe, and the Berezinskiy Biosphere Reserve.

(2) Towards a Green Revolution in forestry

A forestry officer explains details of an FAO-assisted forestry development project to villagers near Kathmandu, Nepal.

NATURE employs a wide variety of methods for expanding tree cover—coconuts that float between tropical islands, aerodynamic seeds and luscious fruits that attract animal carriers. Strategies equally diverse and ingenious are needed to mobilize human energy and financial resources for tree planting sufficient to satisfy fuelwood needs, stabilize soil and water resources and slow the carbon dioxide build-up.

Tree planting programmes are most effective when local people are involved in their planning and implementation and perceive their own interest in success. If fodder is a critical need, for example; a project that promotes a non-browsable species like eucalyptus will receive little popular support. Designing a reforestation project without local input is like letting a doctor prescribe treatment without asking the patient what hurts.

A number of tree planting programmes are meeting with considerable success. In Haiti a project to encourage agroforestry and tree farming has included planting more than 27 million seedlings between 1982 and 1986.

Around the world, women's associations, peasant collectives and church groups have taken up tree planting; in Kerala, India, alone, some 7,300 organizations are involved.

In Kenya, the Greenbelt Movement, sponsored by the National Council of Women of Kenya, has involved more than 15,000 farmers and half a million schoolchildren in establishing 670 community nurseries and planting more than two million trees.

In 1985, annual planting in China doubled to eight million hectares, giving renewed cause for optimism. Tree survival rates that had averaged only 30 per cent may also be improving. China seems unlikely to achieve its ambitious target of 20 per cent forest cover by the year 2000, but the combination of increased planting and better management, if sustained, could mean the nation's tree cover resumes its upward trend.

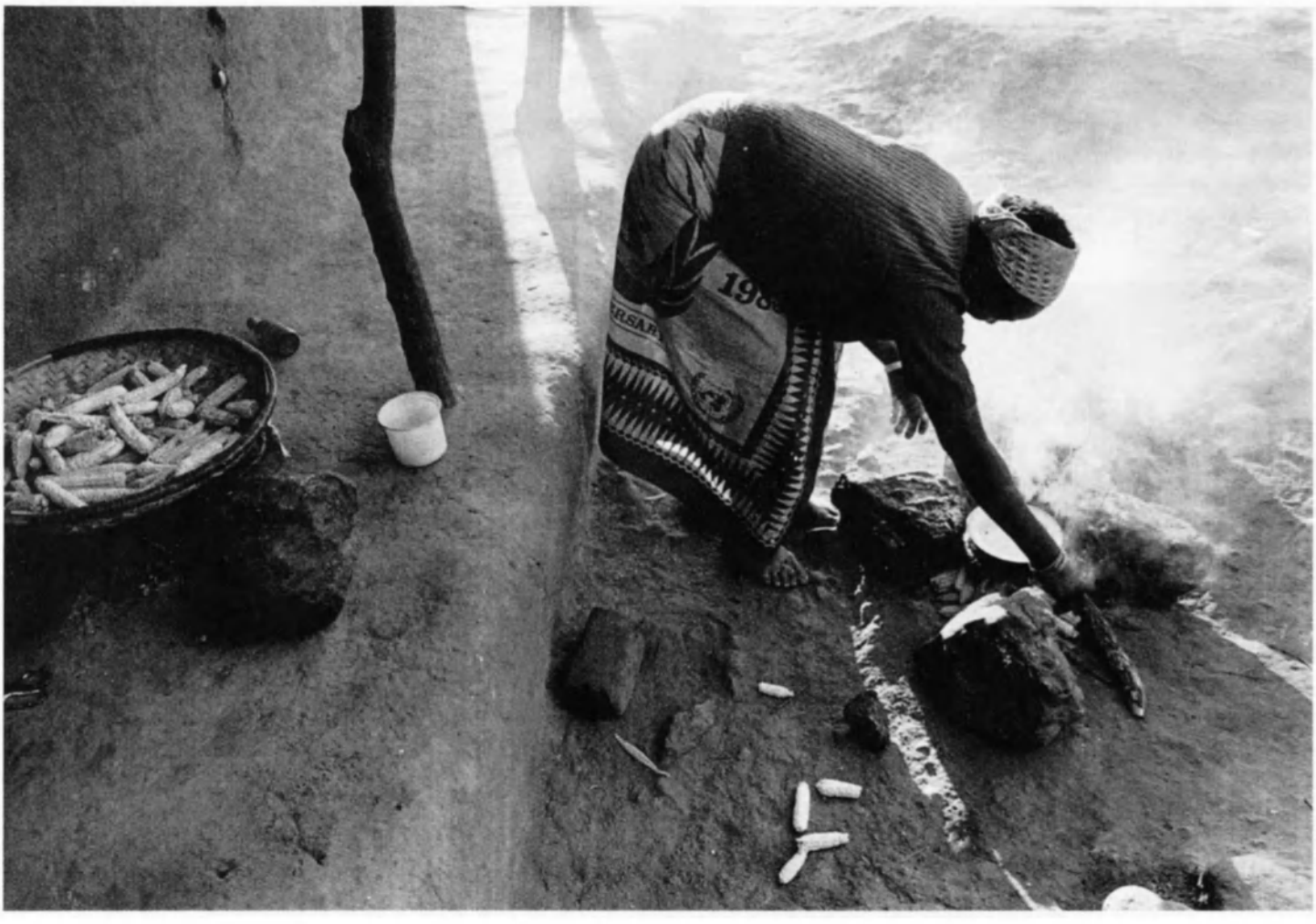
The late 1985 launch of the Tropical Forestry Action Plan holds promise of elevating forestry to its rightful place among development priorities. Jointly sponsored by FAO, UNDP (the United Nations Development Programme), the World Resources Institute and the World Bank, the Action Plan calls for accelerated investments of $8,000 million over five years in tree-planting projects and efforts to arrest deforestation.

In his development agenda for 1985 to 1990, Indian Prime Minister Rajiv Gandhi assigned forestry a central place. He almost tripled funding for forestry, reorganized his Ministries to give forestry new prominence and created a National Wastelands Development Board to spearhead a "people's movement for afforestation".

What is needed in the coming decade is an effort somewhat akin to the agricultural Green Revolution of the 1960s; a dedication to developing genetically improved tree species and to extending widely the technical and financial resources for reforestation. Forestry's Green Revolution, however, needs to promote indigenous tree species and diversified agroforestry systems and must strive to benefit marginalized populations, including the landless. Accelerated planting that does not benefit the poor only masquerades as success. ■

A tree-planting campaign in Lesotho undertaken by the local population.

(3) The fuelwood crisis



Lacking fuelwood, this Zimbabwean woman uses maize residue to cook a meal.

ENERGY planners in developing countries face a markedly different set of challenges over the coming decades than their counterparts in industrial countries. Many of the developing countries remain tightly wedded to wood as a primary energy source, either in its raw form or after conversion to charcoal. As wood supplies in the countryside and around cities continue to dwindle, growing numbers face a deepening energy crisis. Even after more than a decade of increasing recognition of the problem, only halting progress has been made towards satisfying future fuelwood demand.

More than two-thirds of all people in the developing countries rely on wood for cooking and heating. Rural dwellers depend on wood almost exclusively, even in oil-rich Nigeria. In many countries—including most of Africa—wood not only dominates household energy use, it provides more than 70 per cent of energy used for all purposes.

According to the United Nations Food and Agriculture Organization (FAO), in 1980 nearly 1,200 million people in developing countries were only managing to meet their fuelwood needs by cutting wood faster than it was being replaced. Nearly 100 million people—half of them in tropical Africa—could not meet their minimum needs even by over-cutting the woodlands around them. FAO projected that by the year 2000 the number of people lacking wood or over-cutting would reach nearly 2,400 million, more than half the projected developing-world population.

The human and ecological costs of wood scarcity are already high. In rural

parts of the Himalayas and the African Sahel, women and children spend between 100 and 300 days a year gathering fuelwood. Boiling water becomes an unaffordable luxury and quick-cooking cereals replace more nutritious but slower-cooking foods, such as beans. Where fuelwood is critically scarce, people often have no choice but to divert dried dung and crop residues from fields to cookstoves, a practice that diminishes soil fertility and depresses crop yields. In Nepal, for example, this diversion reduces grain yields an estimated 15 per cent.

Rapid urbanization will only magnify the ecological consequences of increasing fuelwood scarcity. City dwellers tend to rely on charcoal rather than wood because its light weight makes it more economical to transport from the countryside. When wood is converted into charcoal in traditional earthen pits, more than half the primary wood energy is lost. This means that every villager who moves to the city and switches from wood to charcoal equals, in energy terms, two people. Even though urban areas have traditionally been less dependent upon fuelwood, urbanization could soon make cities pivotal to national fuelwood strategies. Indeed, the World Bank estimates that by the year 2000 the urban areas of West Africa will account for 50 to 70 per cent of the region's total fuelwood consumption.

In Kenya, charcoal is the preferred fuel for city-dwellers. An improved model (left) of the traditional *jiko* stove can cut a Nairobi household's fuel costs by as much as 50 per cent.

Experts generally agree that a successful strategy to meet the fuelwood needs of the developing countries must include increasing the productivity of natural forests by making better use of wood now wasted, including logging residues and trees cleared for cropland, by raising the efficiency with which the wood is burned and by planting more trees. The World Bank has calculated that fuel substitution and the use of more efficient kilns and cookstoves could reduce fuelwood needs in the year 2000 by about a fourth. Eliminating the remaining gap between projected supply and demand would require planting the equivalent of 55 million hectares of high yielding fuelwood plantations, or 2.7 million hectares per year, given a base year of 1980. If the needed number of trees were planted less intensively on farms, around houses and in woodlots, planting efforts would involve an area at least four times as large. Actual planting for fuelwood has averaged about 550 hectares annually, a fifth of what is needed.

More than a decade of experience with so-called communal and farm forestry projects has shown clearly that inspiring large-scale planting of trees is no easy task. The international donor community rightly recognized during the 1970s that villagers in developing countries themselves formed the only labour force large enough to plant trees on the vast areas needed. In many cases, however, rural people were reluctant to participate in communal planting because they had no idea how the resulting benefits would be shared. Perhaps the greatest lesson of the first generation of fuelwood projects was that villagers were rarely motivated to plant trees exclusively for fuelwood.

To outside observers it seems irrational for people faced with an energy crisis to be reluctant to plant trees for fuel. But for most rural dwellers in developing countries, fruit, poles, fodder and shade are higher priorities. They know that wood, in the form of trimmings and dead branches, will be a secondary benefit of plantings for these other purposes. Moreover, people do not always perceive the national "fuelwood gap" that so concerns energy planners. They may be cutting wood over and above a sustainable level, yet still not be experiencing an unacceptable shortage. And in rural areas where fuelwood is not part of the cash economy, the cost of increasing scarcity is measured in women's time, something that may have little value to male decision-makers.

The key to mobilizing villagers is to promote multi-purpose trees that meet their immediate needs while also increasing the woody biomass available for fuel. Particularly promising is the potential of agroforestry—the combined production of crops and trees—to raise crop yields while providing fuelwood and other useful products. Nitrogen-fixing trees planted in shelterbelts or interspersed with crops, for example, can enhance soil fertility, increase soil moisture and reduce erosion.

Agroforestry programmes offer a

number of advantages over more traditional approaches to addressing the fuelwood crisis. They typically cost only 10 to 20 per cent as much as government-established fuelwood plantations. Although yields per hectare may be higher in plantations, agroforestry often results in greater wood production per planted tree. Through pruning techniques known as coppicing and pollarding, a single tree can yield five to ten times the wood volume that a plantation tree would yield upon felling. And in contrast to communal woodlot projects, agroforestry does not pose problems with shared work loads, division of benefits or the displacement of other productive uses of common land, such as grazing.

In parts of the African Sahel, women and children spend up to 300 days a year gathering fuelwood.

Of course, agroforestry does not address the fuelwood needs of the millions of rural people who do not own land. Traditionally they have had to collect wood from common lands or steal it from forest reserves. Providing fuel for the landless may well be the greatest energy challenge facing governments in developing countries today.

In India, the Government of West Bengal addressed this problem by allo-

RINGS OF TIME

In addition to the many other benefits they bestow upon mankind, trees provide us with an accurate natural calendar and climatic record.

Many species of tree produce a ring of new wood every year. The width of the ring (i.e. the amount of growth) for each year is determined partly by internal, genetic factors and partly by external factors such as soil and, particularly, climatic conditions. In a bad year, poor growth is reflected in a narrow ring, whereas a wide ring indicates favourable climatic conditions and good growth. All trees of one species within a particular area tend to show similar patterns of rings.

This makes it possible, for example, to establish the date that a particular tree was felled by comparing the pattern of rings of its stump with that of a living tree in the same forest. A 200-year-old tree will have a pattern for one hundred of its rings in common with a tree of the same species that was cut down one hundred years ago. By making use of such overlapping patterns and by studying wood from ancient buildings and trees preserved in bogs and fenlands, dendrochronologists (scientists who study the chronological sequence of annual rings in trees and aged wood) have succeeded in establishing master chronologies which, for certain areas, go back to about 5000 BC.

Master chronologies enable archaeologists and historians to date with accuracy buildings of which there are no written records and to see how climatic conditions varied from one part of a particular area to another. They also provide a means of verifying the accuracy of Carbon-14 dating methods.

THE GREENHOUSE EFFECT

CARBON dioxide in the atmosphere has an important effect on world climate. It lets through most of the short-wave energy directed at the Earth by the Sun, but retains a high proportion of the long-wave energy radiated back by the Earth out toward space. This is known as the "greenhouse effect", by analogy with the garden greenhouse whose glass windows admit solar radiation, but partially trap the infra-red radiation re-radiated from within. This causes the temperature in a greenhouse to rise to a higher level than that of the free air outside.

Because of the rise in carbon dioxide concentration in the atmosphere (from 265 parts per million in 1850 to 340 parts per million in 1985), due primarily to the combustion of fossil fuels (e.g. coal, oil and natural gas), scientists predict that significant changes in climate patterns will occur by the end of the century. They foresee a rise in average global temperature of between 3^0 and 5^0 Centigrade before the year 2010.

Temperature increases in the Polar regions could be three times the global average, which would result in rapid melting of the Polar ice caps. Sea levels could rise by as much as 5 to 7 metres causing flooding of vast areas of low-lying land.

Trees normally act as a sink for carbon dioxide, which they "inhale", returning oxygen as waste to the atmosphere as they "exhale". However, when trees are cleared or burned, the carbon they contain, as well as some of the carbon in the underlying soil, is oxidized and released to the atmosphere. Since 1860 some 90 to 180 thousand million tons of carbon has been released to the atmosphere as a result of forest clearing, as compared with 150 to 190 thousand million tons from the burning of coal, oil and natural gas.

Many scientists consider the warming of the atmosphere as posing one of the most serious environmental threats to man. And forest clearance is doubly harmful since not only is the carbon "sink" effect of trees lost, but more carbon is released to the atmosphere.

A charcoal kiln at the Subri River Forest Reserve, Ghana. Waste wood from forest clearing that was once burned is now converted into charcoal.

cating more than 5,000 hectares of denuded forestland to landless families for cash-crop tree farming. Though families were not ceded title to the land, they were granted ownership of the trees. To encourage participation, the Forest Department supplied free seedlings, fertilizer, technical assistance and insecticide, and it offered small cash incentives based on the number of trees surviving after three years. The families harvested the wood for sale after five years and with the proceeds bought small parcels of land suitable for farming. While the trees matured, villagers collected twigs and branches for fuel. Where a strong commercial market for wood exists and

sufficient degraded forestland is available, such a strategy can bring non-productive land into use while providing the landless with both fuelwood and added income. Meeting future fuelwood needs will depend as much on managing demand as on increasing supply. Many policies that could significantly reduce demand attack the broader economic and social conditions that underlie fuelwood shortages. If birth rates today in Africa were no higher than those in Asia, for example, Africa's demand for fuelwood forty years from now would be reduced by as much as 30 per cent.

Improving the efficiency of cookstoves in developing countries is also crucial. Such efforts will never completely solve the fuelwood crisis as population growth would soon outstrip even the most ambitious dissemination programme. But improved stoves can benefit individual households while collectively relieving pressures on natural woodlands until tree planting programmes take hold.

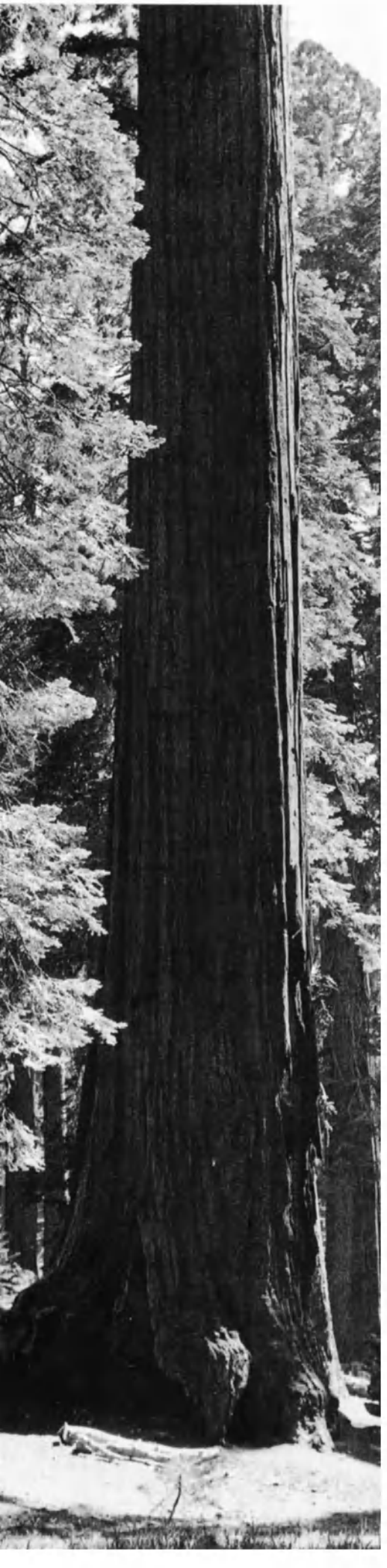
Particularly promising are prospects for reducing wood consumption in cities, where rising wood and charcoal prices provide a powerful incentive to invest in efficiency. An improved model of the traditional charcoal *jiko* in Kenya can halve fuel use. For the average Nairobi family spending 170 shillings (about $8.35) a month on charcoal, the stove pays for itself in just two months.

In rural households, where wood is gathered rather than purchased, no direct economic advantage exists to boost wood-burning efficiency. Yet women, who spend much time collecting wood, have an incentive to construct improved stoves if they can do so from free, locally available materials. A particularly successful programme in Burkina Faso promotes an up-graded version of the traditional three-stone cookstove, surrounded by a cylindrical shield made of mud, dung and chaff. The new model cuts wood use by 35 to 70 per cent, takes only half a day to make and costs virtually nothing. ■

SANDRA POSTEL and **LORI HEISE** are senior researchers with Worldwatch Institute, Washington, D.C., a non-profit research organization which was created to focus attention on global problems and is funded by private foundations and United Nations organizations. The above article and those on pages 13 and 18 have been extracted from *State of the World 1988: A Worldwatch Institute Report on Progress Toward a Sustainable Society* (W.W. Norton, New York/London, 1988).

Pollarded alders, Nagaland State, north-eastern India. Through pruning techniques known as pollarding and coppicing, a single tree can be made to yield five to ten times the volume of wood a plantation tree would yield on felling.

Arboreal oddities



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The biggest tree (1)

The largest single living objects on Earth are the Sequoia Pines (*Sequoiadendron giganteum*) growing in the Sequoia National Park, California. The largest of them, known as the General Sherman, stands 83 metres tall and has a true girth (at 1.53 metres above the ground) of 24.11 metres.

The smallest tree (2)

Bonsai (a Japanese word meaning "tray-planted") trees are ordinary trees and shrubs, not hereditary dwarfs, that are dwarfed by pruning their roots and branches. Average-size bonsai trees grow to a height of around 60 centimetres, but miniature bonsai may be a mere 5 centimetres tall.

3

The oldest tree (3)

The oldest known living tree is a 4,600-year-old bristlecone pine (*Pinus longaeva*) named Methuselah, growing in the Sierra Nevada, USA. Photo shows a bristlecone pine at the Inyo National Forest, California.

The trees with the largest girth (4)

Baobab trees hold the record for tree girth. Their barrel-shaped trunks may measure up to 10 metres in diameter.

The fortress tree (5)

In olden days the people of the villages of Kimré, Modé and Bordo, in Chad, built fortresses for defence against marauding bands in the huge branches of the kapok tree (*Ceiba pentandra*). The illustration is from an account of an expedition by the German explorer Gustav Nachtigal (1834-1885).

The oak tree with two chapels in its trunk (6)

Next to the church at Alouville-Bellefosse, near Yvetot, in the Seine-Maritime Department of France, stands an oak tree (*Quercus robur*) over a thousand years old within whose hollow trunk two chapels have been constructed. In 1698, the lower chapel (below) was dedicated to Notre Dame de la Paix.

6

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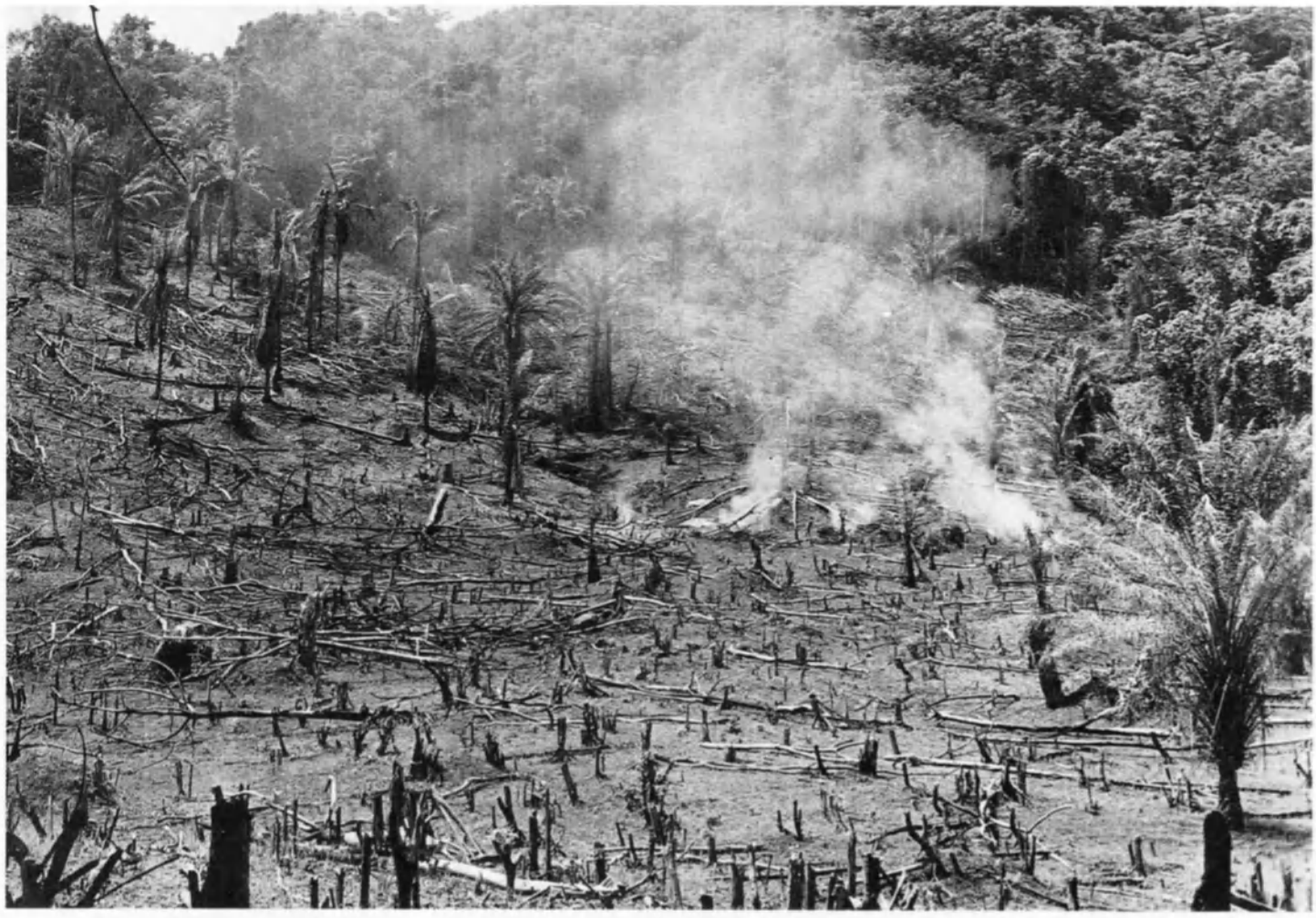
5

BY MALCOLM HADLEY

Farming the forest



Fire is a tool used extensively in the tropics in the shifting agriculture cycle. Above, a plot being burned prior to planting.

SHIFTING cultivation has for centuries been practised successfully, and with no harmful environmental effects, by root-crop farmers of the humid tropics and by dry-rice cultivators of the forested hill regions of Southeast Asia.

Though it has many variations, this widespread form of agriculture, also known as swidden or slash-and-burn agriculture, basically involves clearing small areas of forest for crop planting by cutting down and burning trees and vegetation. The ash acts as a fertilizer and the plot is relatively free of weeds. After a few years of cultivation, however, the fertility of the land declines and weeds increase. The shifting cultivators then move on to another area, abandoning the plot to natural regrowth and recuperation during a fallow phase before returning to the same plot a number of years later.

Traditional cyclical shifting agriculture is based on sound ecological principles and in the past represented a sustainable use of the forest. In India, this *jhum* cycle, as it is called, used to stretch over thirty years or more, which gave a reasonable time for recovery of the forest and the soil as well as yielding acceptable returns to the farmer. The entire *jhum* operation involved efficient recycling of resources to maximize yields, by such means as using crop and weed residues as organic manure and as feed in swine husbandry.

However, increased population pressure (in northeast India population more than quadrupled between 1900 and 1975) and reduced land area due to site degradation have forced farmers to

Crops growing in a clearing created by the "slash-and-burn" technique. Borneo, Indonesia.

resort to very short *jhum* cycles of only four or five years. In turn this has accelerated the land degradation spiral, further slowed the recovery of soil fertility and diminished economic returns.

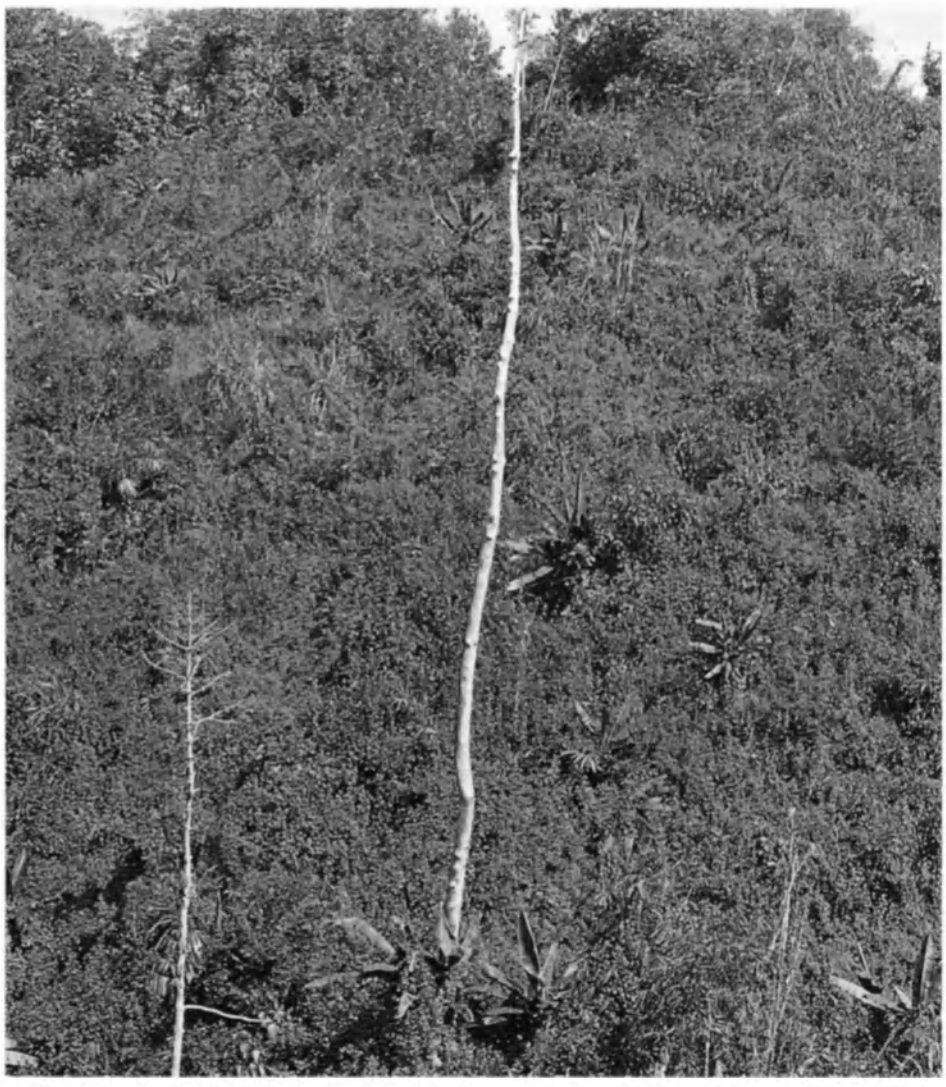
Rapid population growth in many tropical areas, combined with the many other social and ecological changes that have occurred over the past two decades, has been accompanied by a relentless increase in the rate and extent of forest clearing and the intensity of forest exploitation. Small-scale cultivators, estimated to number some 250 million, cause final elimination of around five million hectares of forest a year and serious degradation of a further ten million hectares. Although these farmers are well aware that their activities are harmful both in general terms and in terms of their own long-term prospects, they have nowhere else to go and no alternative employment outlets.

Because of the rapidity of these changes, it is important that more effective, sustainable forest exploitation be linked with development that benefits people who live in or near the forest and who make use of it. Attempts to achieve these objectives have, however, been hampered by lack of information on how people in various parts of the tropics interact with the forest and how they respond to changing economic opportunities.

Under Unesco's Man and the Biosphere (MAB) Programme, several field studies have been made to investigate this problem. One of these studies, conducted in East Kalimantan, Indonesia, produced some unexpected results.

The remote interior Apo Kayan plateau is the homeland of several thousand Kenyah people who live in long-house communities and practise forest-fallow shifting cultivation. The study revealed that, far from being the reckless destroyers of forest that they had long been thought to be, the

Weed invasion under a short shifting agriculture cycle. The plot is covered with *Mikania michantha*, a weed which contributes to the regeneration of soil fertility.



Kenyah people maintain, tend and reuse sites. For the last 200 years at least, there has been a fairly consistent conservative pattern of forest exploitation. In the Apo Kayan, the Kenyah have converted the virgin forest into a mosaic of secondary forest of different ages plus unfelled reserves where they can harvest products that are rare or non-existent in secondary forest.

Most swiddens (sections of forest cleared for agriculture by cutting and burning) are created on more fertile soils, on slopes of intermediate grade, and in secondary forest eight to twenty years old, with primary forest reserves being maintained close to the villages.

Results of studies on the seed bank (the seeds actually present in the soil), of sampling of one- to four-year-old fields and of surveys of secondary forest, provide consistent evidence that shifting cultivation at Apo Kayan is a forest-maintaining agricultural system. Those tree species common in secondary forest seem to be particularly well adapted to regeneration after shifting cultivation because they re-sprout or their seeds survive burning.

Many of the cyclical agroforestry systems studied to date in the tropics have been those practised by relatively remote tribal groups that are largely outside the chain of active commerce. This suggests that such systems of resource management are suited only to subsistence production. However, recent investigations carried out by a number of independent researchers indicate that they can also be important cash producers.

One study examined a market-oriented system practised by farmers at Tamshiyacu, Peru. The Tamshiyaquinos are a non-tribal group, some 2,000 strong, of mixed Amazonian and European ancestry, living about 30 kilometres southeast of the regional market centre of Iquitos. They engage in a large number of agricultural and extractive activities, exploiting a wide variety of the land and water resources available to them.

The techniques used by the Tamshiyaquinos include the farming of upland sites under both high forest and fallow growth of varying ages, the cultivation of seasonally inundated, low-lying sites, as well as fishing, hunting and the extraction of a variety of forest products. Foods, fibres, handicraft materials and charcoal are among items obtained from the fields and forests of Tamshiyacu that appear on the local market and the urban market of nearby Iquitos.

The agroforestry cycle begins with the cutting of the standing vegetation. In secondary forest areas, the Tamshiyaquinos cut down the vegetation but do not burn it in the typical slash-and-burn fashion. Instead, the larger woody vegetation is usually converted into charcoal.

After clearing, a variety of crops, such as corn, rice and cow-peas, are planted. Some of these crops are re-planted during the second year, together with a number of other crops such as manioc and peanuts, and a start is made on the planting of fruit and nut trees.

Annual crop production is gradually phased out after an initial two- to five-year period. Fruit and nuts from the trees become the most important source of income from the plot and production may continue for twenty-five to fifty years if the fields are protected from cattle. At first, fruit and nut crops are picked from selected trees, but this is gradually reduced in frequency to once or twice a year, just before the harvest of the Umari, the most important tree crop. As soon as production drops significantly (after between about twenty-five and fifty years) the larger items of vegetation (the Umari and the Brazil nut trees) are cut down and converted into charcoal.

Following this second round of charcoal-making, the field is generally allowed to lie fallow for six years or so. Secondary growth invades the plot and, according to local farmers, begins to restore it so that another production cycle can be set in train.

Most households have several agroforestry fields operating at any one time. Since these are in different stages of the production cycle, farmers tend to obtain an income from the sale of a variety of resources. This limits the risks inherent in specialization, spaces out the need for often scarce labour and assures households of some cash flow throughout the year.

The limited observations so far made indicate that, thanks to their cyclical agroforestry methods, the Tamshiyaquinos enjoy some of the highest average annual incomes to be found among rural dwellers of the region. In one survey of thirteen villages in the Iquitos region, some Tamshiyacu households were found to have gross yearly incomes of nearly $5,000, and the mean for village households, some $1,200, was still above average.

The results of these people/environment studies highlight a way forward in the search for an improved basis for ecologically sound development in the tropics—that of integrating the resource-based knowledge of local people (in such areas as multiple-cropping and the manipulation of swidden fallows) with modern technological know-how in flexible ways that are capable of adapting and being adapted to changing social and economic circumstances. ■

One stage in a long shifting agriculture cycle: the ground has been cleared but tree stumps have been left in situ.

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BY ILLAR MUUL

'Use them or lose them'

A recipe for sustainable use of tropical forests

The gaur (*Bos gaurus*), a forest-dwelling bovine of Malaysia

CURRENT estimates indicate that about half the world's tropical rain forests have already disappeared. The remainder are rapidly being destroyed. Much of the blame for this has been placed on the demand for timber by industrialized countries. But it seems that only about 15 per cent of the felled trees are exported. World timber demand has actually declined somewhat in recent years and many timber producing countries are finding that only the most desirable wood, such as species used for expensive veneers, is worth cutting and hauling out of the forests. Unfortunately, hundreds of trees of lesser value are destroyed to get access to the expensive trees, and the building of roads, loading areas and logging camps destroys large tracts of forest.

Watering seedlings at the tree nursery of a forestry rehabilitation and diversification project in north-eastern Thailand.

Another major cause of forest destruction is a variety of agricultural schemes. Tropical rain forests are quite tolerant of limited traditional shifting agriculture (see article page 26) and have a great capacity to regenerate if not over-exploited. But, when forests are totally cut and replaced by monocultures, in many areas the relatively poor soils cannot support more than a few years of harvest. Rain washes away the thin layer of topsoil. The harsh sun bakes the remaining soil until it is too hard to absorb the torrential rains of the monsoons. Flooding occurs downstream and hydroelectric generating dams and irrigation schemes become clogged with silt. Climatic changes occur, accentuating the differences between seasons with too much rain and those with too little.

All these are sound ecological arguments for action to conserve the world's remaining tropical rain forests. But with rapidly rising populations hungry for food and land, crippling foreign debt repayments to make and with the terms of trade turning against them, the developing countries within whose territories these forests lie have more immediate economic and social problems to resolve. In these circumstances they have little option but to attempt to sell yet more timber and to clear more forest for agricultural use even though they know this to be against their long-term interest.

How can these long-term assets be saved? It needs to be demonstrated that sustainable use of tropical forests will provide more local and national income than clear-cutting and low productivity

agricultural schemes, and that forest conservation must be coupled with economic development.

The exhortations of conservationists for further research need to be linked to action to provide alternatives to present misuse. The contribution of the tropical rain forests to the maintenance of local climatic patterns, particularly rainfall that maintains agricultural productivity, needs to be convincingly demonstrated. Above all, the economic payoff must be immediate to forestall continuing destructive use of the forests.

Integrated Conservation Research (ICR), a US ecological group, has launched a series of programmes in Malaysia and China which are aimed at demonstrating that rain forests are more valuable if used on a sustainable basis than if cut down for immediate, short-term profit. The goals are to protect the species diversity that exists in those forests and to expand the land areas under protection. ICR's work is supported by Unesco's Man and the Biosphere (MAB) Programme, which first proposed the concept—now accepted by most conservation-oriented groups—of coupling economic development with conservation.

▲ A forestry extension officer shows a member of a commune in Hunan Province, China, the correct method of planting tea oil seeds.

◀ Logs for export float down a river in Borneo, Indonesia

The economic development aspect of the ICR programmes is divided into three main areas of effort: agroforestry, ethnobotany, and natural history-oriented tourism.

Increasing numbers of tropical ecologists are becoming convinced that multiple species communities are more likely to survive and be more productive than monocultures. This idea is fundamental to agroforestry. An excellent example of this in a very simple "community" is to be seen in the Southern Yunnan Province of China.

Rubber has been successfully grown in Xishuangbanna, far north of its major distribution in Southeast Asia. However, in an unusually cold year, many of the rubber trees died. Intensive research resulted in a decision to plant the rows of trees farther apart than is the usual practice in areas farther south, to allow better air circulation at the tree bases. This enhanced tree survival because lethal fungus, encouraged by cold and damp conditions, did not reach harmful levels.

Between the rows of trees, tea was planted in order not to waste the space. The tea plants became more productive under the partial shade of the rubber trees. The vegetation "community" (two species) also supported a "community" of more than one hundred species of spider. These were more efficient than spraying in eliminating the pest species of insect that feed on tea plants. Money was saved by not spraying, the product was cleaner and environmental contamination with insecticides was eliminated.

ICR will attempt to combine many species in agroforestry schemes, including traditional and new food plants, medicinal plants, commercially valuable timber, fuel wood, and newly domesticated animals.

The most striking among the animals is a species of forest-dwelling cattle known as the gaur (*Bos gaurus*). These magnificent animals are nearing extinction as forests disappear and render them more vulnerable to hunters. Their meat is highly prized, low in cholesterol and comprises 65 per cent of the carcass, which often weighs nearly two metric tons. Mohd Khan, the Director-General of Wildlife and National Parks in Malaysia, is very concerned about these unique animals and has developed a programme for captive breeding to reintroduce them to areas where they have become extinct. He is also interested in developing domestic strains for beef production.

The Department of Veterinary Sciences in Malaysia has a programme of hybridization of the gaur with domestic cattle. The hybrids grow 60 per cent faster than domestic cattle. The pure breeds may, however, have an advan-

tage, partly because they are very heat tolerant. They are the only species of bovid that sweats. Moreover, their sweat contains repellents against flies, ticks, and other ectoparasites, which means that they are less susceptible to infectious diseases carried by these parasites.

The most important characteristic of this species, however, is that it does not require grass for food. It is a browser of forest edge plant species. Consequently, forests do not need to be destroyed to propagate it. The forests are capable of supporting herds of limited size without irreversible damage to species diversity. Embryo transplants into domestic cattle are planned to accelerate the breeding programme. Research support for this programme is being provided by the Smithsonian Institution's National Zoo in Washington, D.C., and the Henry Doorley Zoo in Omaha, Nebraska.

Plants used in traditional medicine will also be used in the agroforestry schemes. One plant, in the Trillium group, is used by inhabitants of Yunnan to help heal wounds, cure ulcers, and stop bleeding after childbirth. The Kunming Institute of Botany, at Xishuangbanna, China, has isolated the active ingredients from these plants. Analyses have revealed their chemical structure, and work is continuing on the testing of the effects of these materials and on the genetics and propagation of the plants, which grow only in the forests. Prospects for their commercial propagation in agroforestry schemes are very promising.

Schemes such as these attempt to demonstrate the nature of the forest as a resource. With research and education, the productivity of these areas can be diversified as the economic potential of new species comes to light.

ICR'S programmes also involve natural history-oriented tourism. Most people are interested in Nature, and natural history tourism offers a potential source of income at the national as well as the local level. Moreover, both visitors and

the local inhabitants would come to better appreciate the value of natural resources.

To make the forest species more accessible for observation (and research) special techniques will be used to bring observers to the canopy level. This is where the dynamics of the tropical rain forest occur. Experience indicates that animals are far less fearful of people when they are encountered in the canopy. On the ground, humans are characteristically regarded as hunters and are feared.

The technique consists of a series of suspended walkways supported from the crowns of the tallest (and strongest) trees. The US MAB National Committee has provided funding for these walkways for research purposes in Malaysia and China. A section of the walkways connects the system to a hillside. Consequently, one can walk into the canopy horizontally without the necessity of a vertical climb. Platforms in the tall trees are used for observation and photography. Artificial lighting at night will be used to observe species not active by day.

Visitors to Kinabalu National Park in Borneo will be able to see newly-planned facilities, including an orchid garden containing most of the native species, a butterfly farm, and a deer park. Nature trails allow them to see many of the 3,500 species of trees that occur on the island, a bat cave and a magnificent waterfall. At the end of a hard day they can soak away their

weariness in natural hot springs that are piped into tiled tubs.

The tours currently last two weeks, but special arrangements can also be made. Through tourism it is hoped to demonstrate the immediate value of the rain forests and to expand existing protection schemes.

From the practical standpoint, the old adage "Use them or lose them" seems to apply to rain forests. It is hoped that both economic developers and conservationists will benefit from sustainable use of forest resources.

Much can be learned from the people who inhabit these forests concerning useful products. They are not the ones who advocate destruction of forests and replanting the land in monocultures. In many cases they have a remarkable respect and regard for the forests, which have provided them with the means to survive for generations. With the destruction of the forests they see their own cultures and survival threatened.

ICR has offered to work with these people in agroforestry schemes, using species with which they are familiar. Through these schemes the group hopes to restore abandoned lands which were formerly covered by rain forests, but have been depleted of nutrients. Leguminous plants which rapidly restore the nutrients in soil have been identified. These plants can also be used as highly nutritious (17 per cent protein) fodder for livestock, such as the gaur and the mouse deer. Medicinal plants will be included, together with a variety of food plants. Assistance will be provided in marketing.

If this can be achieved in China and Malaysia, the forests will have paid their own way. At a planning workshop held in October 1988, ICR set a goal of self-sufficiency within four years for its research and economic development programme. Many of the several dozen participants expressed scepticism. Ecologists are not accustomed to thinking in such terms. But more of us need to think in these terms if we are to achieve our goals of saving significant amounts of tropical rain forests. ■

Walkways constructed high up in the forest canopy and used by scientists for research can also provide tourists with magnificent views and new insights into the tropical forest.

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The Christianization of Kievan Russia

The Millennium celebrations

The thousandth anniversary of the introduction of Christianity to Kievan Russia was widely celebrated during 1988. This report on the highlights of the year's events has been written for the *Unesco Courier* by Monsignor Juvenaly, Metropolitan of Krutits and Kolomna, a leading figure in the Russian Orthodox Church and a member of its Holy Synod.

At a meeting with Patriarch Pimen and the Holy Synod of the Russian Orthodox Church on 29 April 1988, Mr. Mikhail Gorbachev, general secretary of the Central Committee of the Communist Party of the Soviet Union, noted that the State and the Russian Church have "a common history, one birthplace and one future".

The programme of celebrations for the millennium began in June with an assembly of a Local Council of the Russian Orthodox Church, which was held in the Trinity and St. Sergius monastery at Zagorsk, near Moscow. The Council was attended by ecclesiastical dignitaries and lay representatives from Orthodox dioceses around the world. Envoys from many other Christian Churches were present at the opening ceremony.

The Council canonized nine Russian saints; adopted the Statutes of the Russian Orthodox Church aimed at promoting the religious life in society today; and issued a number of appeals and messages to all Russian Orthodox Churches, to all Orthodox Christians practising the old rites, and to Christians all over the world.

The centrepiece of the Moscow events was an open-air service at the Danilov monastery, celebrated before a congregation of many thousands by clergy from Orthodox churches in many parts of the world, led by the Patriarch of Antioch. The monastery, returned to the Church by the Soviet State in 1983 and since restored, is today the spiritual and administrative centre of the Russian Orthodox Church.

Later in June, in a new district of Moscow, Patriarch Pimen laid the foundation stone of a church dedicated to the Holy Trinity to mark the millennium of Russian Orthodoxy.

The celebrations continued in other historic religious centres such as Kiev, Vladimir and Leningrad. Open-air services held in all these cities drew crowds of worshippers.

In Kiev, the cradle of Russian Orthodoxy, the festivities took on a special meaning. The Kiev caves, partly natural and partly man-made structures excavated in the eleventh century, once sheltered the first Russian monks, hermits who had adopted the ascetic way of life. As none of the city's cathedrals was large enough to accommodate the Kievans and pilgrims who wished to commemorate the millennium, a service was held in Lavrskaya Square, near the entrance to the Far Caves, by a number of high dignitaries of the Russian Orthodox Church. Afterwards, clergy and guests entered the holy caves, where psalms were sung in honour of the saints who had lived and died there.

Later, a service of thanksgiving was held on the hill crowned by the statue of Prince Vladimir I of Kiev, who in 988 AD accepted Christianity on behalf of Kievan Russia. Thousands of Christians gathered for the service on the slopes overlooking the place where, a millennium ago, the mass baptism of the people of Kiev took place. Canticles were sung by the choirs of St. Vladimir cathedral and Odessa theological seminary. This service was the outstanding event of the millennium, although celebrations continued nationwide, in all the dioceses of the Russian Orthodox Church. ■

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